



US009998973B2

(12) **United States Patent**
Gao et al.

(10) **Patent No.:** **US 9,998,973 B2**
(45) **Date of Patent:** ***Jun. 12, 2018**

(54) **COMMUNICATING RADIO RESOURCE
CONFIGURATION INFORMATION**

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(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 56 days.

This patent is subject to a terminal dis-
claimer.

(58) **Field of Classification Search**

None

See application file for complete search history.

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(21) Appl. No.: **14/833,767**

(22) Filed: **Aug. 24, 2015**

(65) **Prior Publication Data**

US 2015/0365869 A1 Dec. 17, 2015

Related U.S. Application Data

(63) Continuation of application No. 13/960,187, filed on
Aug. 6, 2013, now Pat. No. 9,125,112.

(51) **Int. Cl.**

H04W 36/22 (2009.01)

H04W 36/00 (2009.01)

H04W 84/04 (2009.01)

H04W 16/32 (2009.01)

(52) **U.S. Cl.**

CPC **H04W 36/22** (2013.01); **H04W 36/0027**
(2013.01); **H04W 36/0072** (2013.01); **H04W**
16/32 (2013.01); **H04W 84/045** (2013.01)

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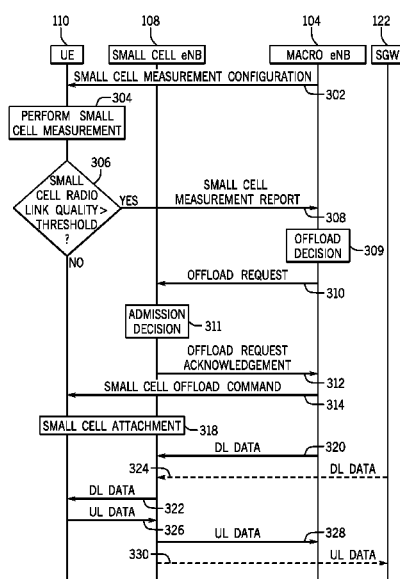
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ABSTRACT

A first wireless access network node receives common radio
resource configuration information of a second wireless
access network node. A data offload request is sent to the
second wireless access network node to perform a data
offload for a user equipment (UE) attached to the first
wireless access network node.

19 Claims, 4 Drawing Sheets



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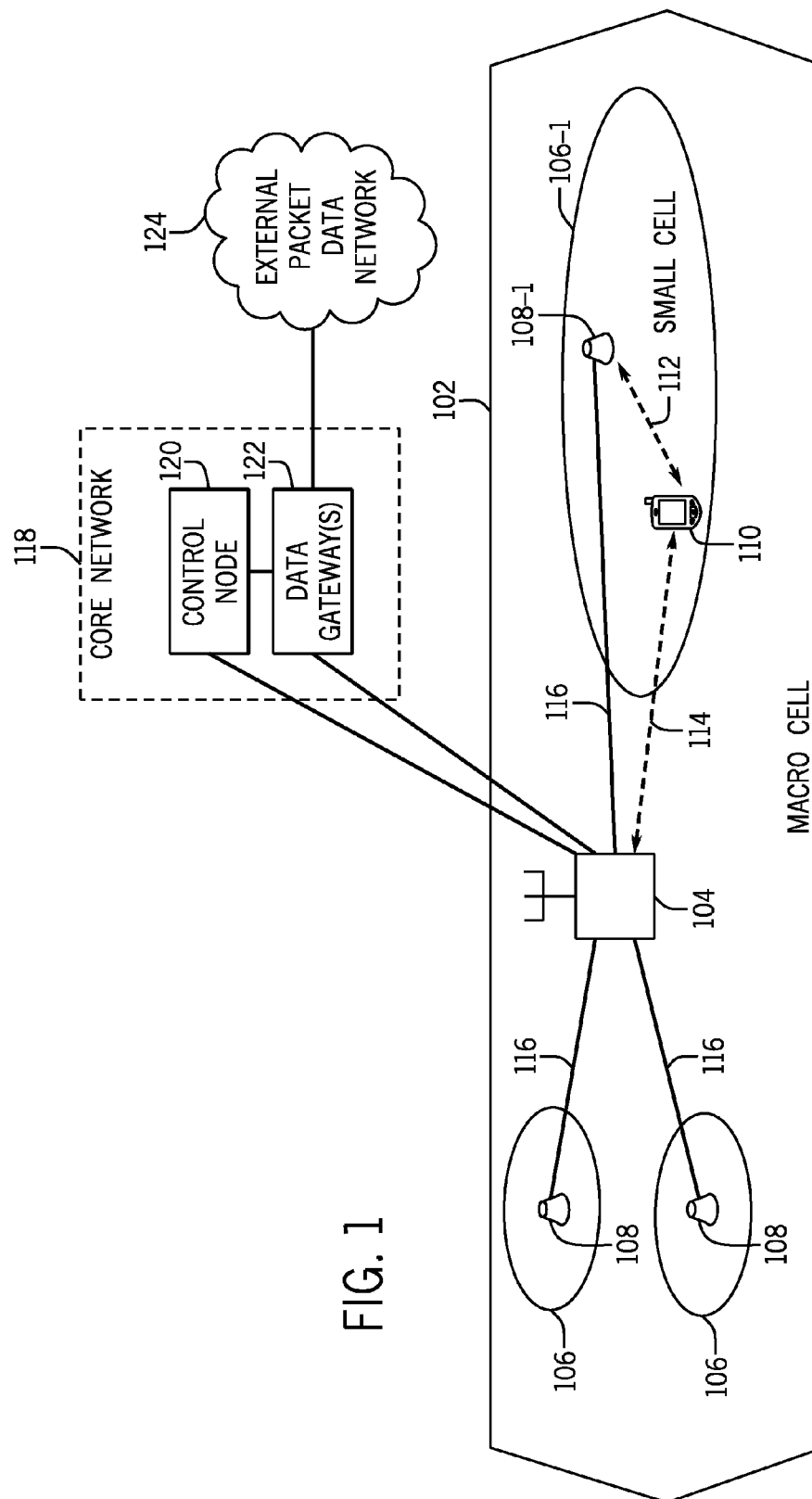


FIG. 1

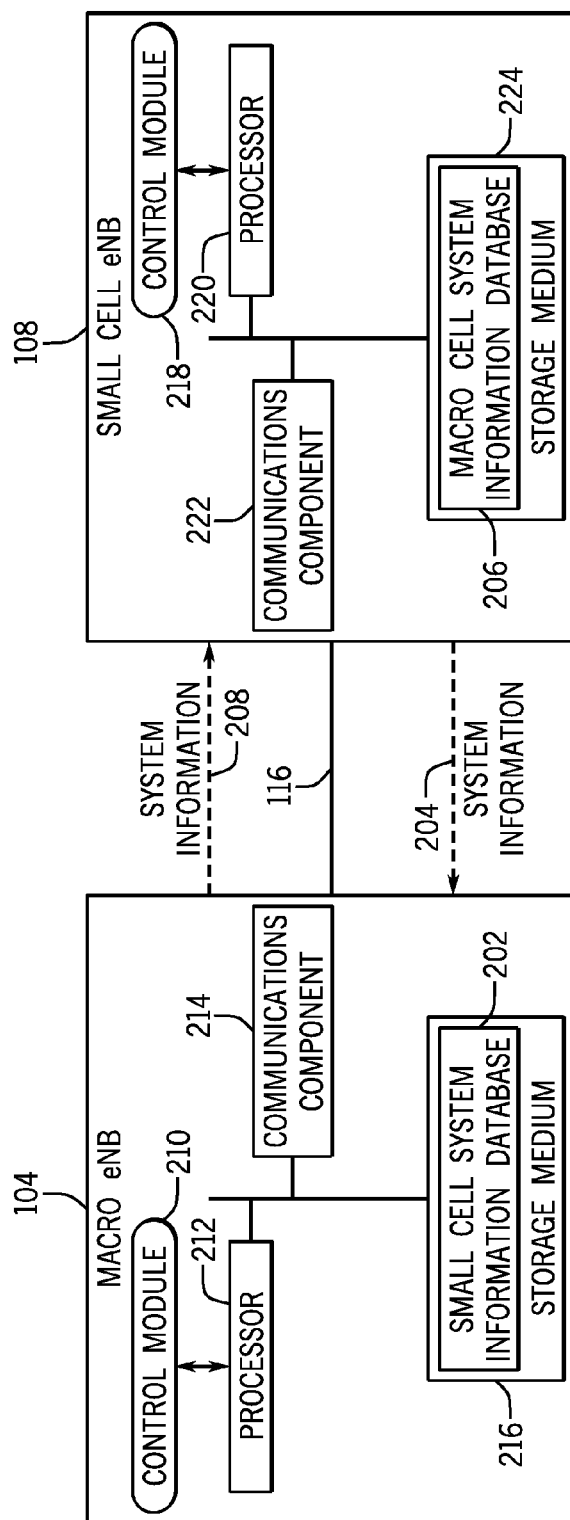


FIG. 2

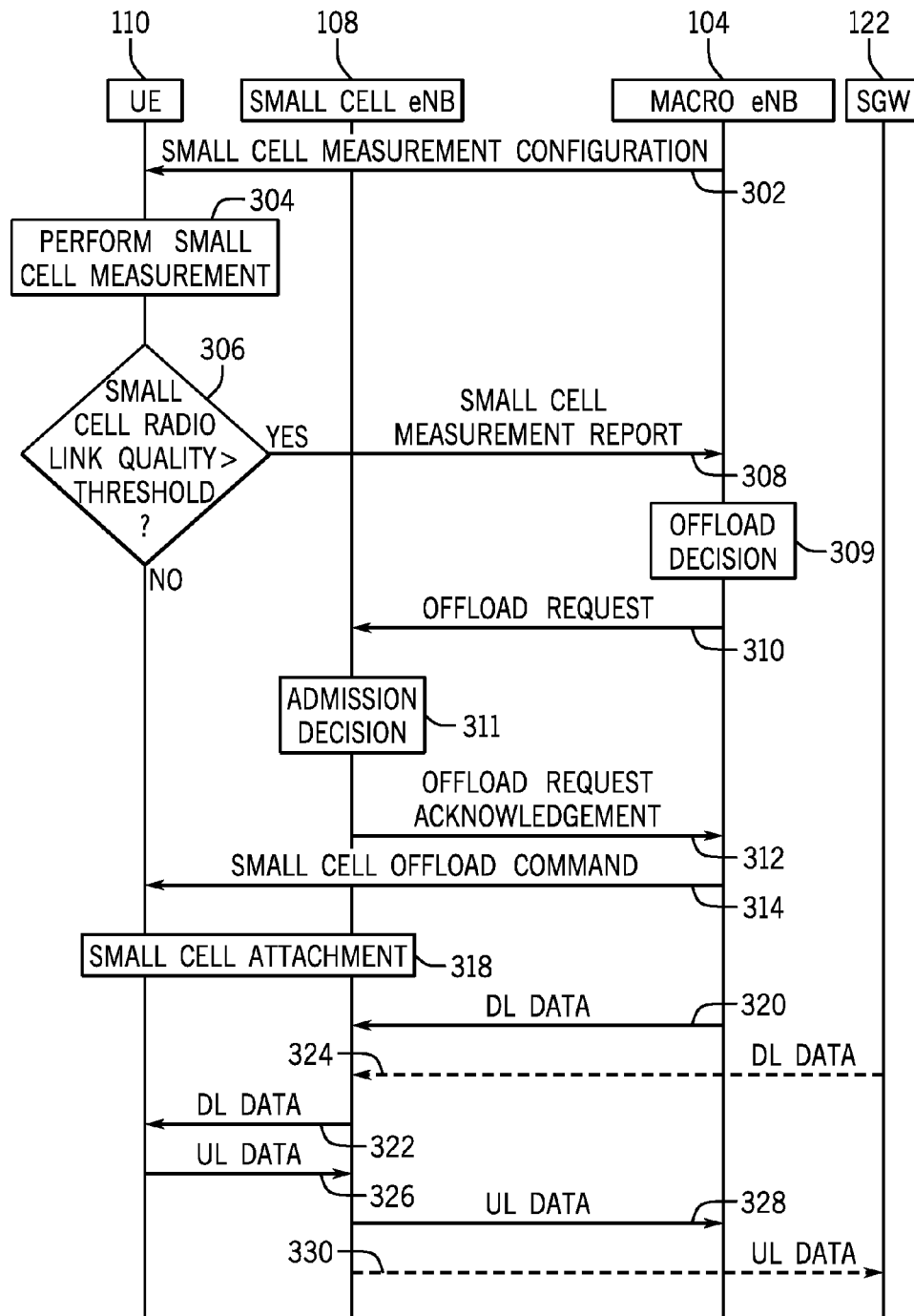


FIG. 3

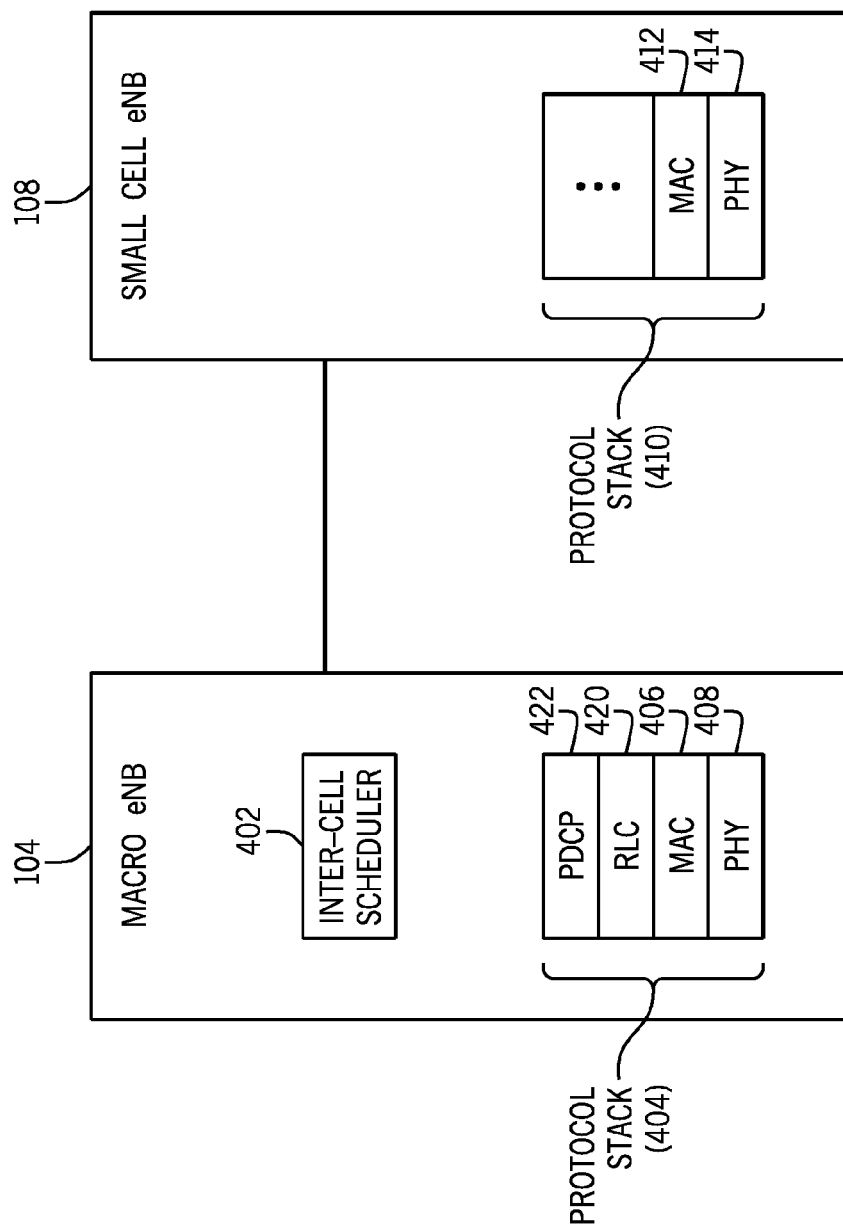


FIG. 4

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COMMUNICATING RADIO RESOURCE CONFIGURATION INFORMATION

CROSS REFERENCE TO RELATED APPLICATION

This is a continuation of U.S. application Ser. No. 13/960, 187, filed Aug. 6, 2013, which is hereby incorporated by reference.

BACKGROUND

As the demand for wireless data communication using wireless user equipments (UEs) has increased, wireless access service providers are increasingly facing challenges in meeting capacity demands in regions where the density of users is relatively high. To address capacity issues, small cells have been developed. A small cell (or multiple small cells) can operate within a coverage area of a larger cell, referred to as a macro cell. A small cell has a coverage area that is smaller than the coverage area of the macro cell.

If small cells are deployed, then data communications with UEs can be offloaded from the macro cell to the small cells. In this way, data communication capacity is increased to better meet data communication demands in regions of relatively high densities of UEs.

BRIEF DESCRIPTION OF THE DRAWINGS

Some embodiments are described with respect to the following figures:

FIG. 1 is a schematic diagram of an example arrangement that includes macro cells and small cells, in accordance with some implementations.

FIG. 2 is a schematic diagram of a macro wireless access network node and a small cell wireless access network node, according to some implementations.

FIG. 3 is a flow diagram of a data offload procedure according to some implementations.

FIG. 4 is a schematic diagram of a macro wireless access network node and a small cell wireless access network node, according to further implementations.

DETAILED DESCRIPTION

FIG. 1 illustrates an example arrangement that includes network nodes that are part of a mobile communications network that supports wireless communications with user equipments (UEs). A node can refer to an active electronic device that is capable of sending, receiving, and forwarding information over a communication channel, and of performing designated tasks. A macro cell **102** corresponds to a coverage area provided by a macro wireless access network node **104**. A coverage area can refer to a region where mobile services can be provided by a network node to a target level. A wireless access network node is responsible for performing wireless transmissions and receptions with UEs. In addition, a number of small cells **106** are depicted as being within the coverage area of the macro cell **102**. Each small cell **106** corresponds to a coverage area provided by a respective small cell wireless access network node **108**. One of the small cells is labeled **106-1**, and the corresponding small cell wireless access network node is labeled **108-1**.

In the ensuing discussion, a small cell can refer to a cell whose coverage area is smaller than the coverage area provided by a larger cell, which is also referred to as a macro cell. In some examples, the frequency at which the macro

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wireless access network node **104** operates can be lower than that of a local wireless access network node **108**. A lower frequency allows a greater geographic reach for wireless signals transmitted by the macro wireless access network node **104**. On the other hand, at a higher frequency, wireless signals transmitted by the small cell wireless access nodes **108** propagate smaller distances. As a result, small cells **106** can be deployed in relatively close proximity to each other.

More generally, the macro cell **102** can use a frequency that is different from one or more frequencies of the small cells **106**. At least some of the small cells **106** can use different frequencies.

A wireless user equipment (UE) **110** within the coverage area of the small cell **106-1** is able to wirelessly communicate with the small cell wireless access network node **108-1**. The UE **110** is also able to wirelessly communicate with the macro wireless access network node **104**. Examples of the UE **110** can include any of the following: a smart phone, a personal digital assistant, a notebook computer, a tablet computer, or any other device that is capable of wireless communications. Although just one UE **110** is depicted in FIG. 1, it is noted that multiple UEs may be present in coverage areas of each of the small cells **106** as well as within the coverage area of the macro cell **102**.

Although reference is made to macro and small cell wireless access network nodes in the present discussion, it is noted that techniques or mechanisms according to some implementations can also be applied to other types of wireless access network nodes.

A first wireless connection **112** is established between the UE **110** and the small cell wireless access network node **108-1**. In addition, a second wireless connection **114** can be established between the UE **110** and the macro wireless access network node **104**. In such an arrangement, the UE **110** is considered to have established dual concurrent wireless connections with the macro wireless access network node **104** and the small cell wireless access network node **108-1**. In other examples, the UE **110** can establish multiple concurrent wireless connections with the macro wireless access network node **104** and with multiple small cell wireless access network nodes **108**.

FIG. 1 also shows a backhaul link **116** between the macro wireless access network node **104** and each of the small cell wireless access network nodes **108**. The backhaul link **116** can represent a logical communication link between two nodes; the backhaul link **116** can either be a direct point-to-point link or can be routed through another communication network or node. In some implementations, the backhaul link **116** is a wired link. In other implementations, the backhaul link **116** is a wireless link.

In some implementations, the macro cell **102** (and more specifically the macro wireless access network node **104**) can provide all of the control plane functions, while a small cell **106** (more specifically the corresponding small cell wireless access network node **108**) provides at least a portion of the user plane functions for a dual-connection capable UE (a UE that is capable of concurrently connecting to both macro and small cells). Note that the macro wireless access network node **104** can also provide user plane functions for the dual-connection capable UE.

Control plane functions involve exchanging certain control signaling between the macro wireless access network node **104** and the UE **110** to perform specified control tasks, such as any or some combination of the following: network attachment of a UE, authentication of the UE, setting up radio bearers for the UE, mobility management to manage

mobility of the UE (mobility management includes at least determining which infrastructure network nodes will create, maintain or drop uplink and downlink connections carrying control or user plane information as a UE moves about in a geographic area), performance of a handover decision based on neighbor cell measurements sent by the UE, transmission of a paging message to the UE, broadcasting of system information, control of UE measurement reporting, and so forth. Although examples of control tasks and control messages in a control plane are listed above, it is noted that in other examples, other types of control messages and control tasks can be provided. More generally, the control plane can perform call control and connection control functions, and can provide messaging for setting up calls or connections, supervising calls or connections, and releasing calls or connections.

User plane functions relate to communicating traffic data (e.g. voice data, user data, application data, etc.) between the UE and a wireless access network node. User plane functions can also include exchanging control messages between a wireless access network node and a UE associated with communicating the traffic data, flow control, error recovery, and so forth.

A small cell connection can be added to or removed from a UE under the control of the macro wireless access network node **104**. In some implementations, the action of adding or removing a small cell for a UE can be transparent to a core network **118** of the mobile communications network. The core network **118** includes a control node **120** and one or more data gateways **122**. The data gateway(s) **122** can be coupled to an external packet data network (PDN) **124**, such as the Internet, a local area network (LAN), a wide area network (WAN), and so forth. FIG. 1 depicts the macro wireless network node **104** connected to the control node **120** and data gateway(s) **122** of the core network **118**. Although not shown, it is noted that the small cell wireless access network nodes **108** can also be connected to the core network nodes.

Note that a legacy UE (a UE that is not capable of establishing dual wireless connections with both a macro cell and a small cell) can connect to either a macro cell or a small cell using standard wireless connection techniques.

When a UE moves under the coverage of a small cell **106**, the macro wireless access network node **104** may decide to offload some of the user plane traffic to the small cell. This offload is referred to as data offload. When data offload has been performed from the macro cell **104** to the small cell **106**, then a UE that has a dual connection can transmit or receive data to and from the corresponding small cell wireless access network node **108**. Additionally, the UE **110** can also communicate user plane traffic with the macro wireless access network node **104**. Although reference is made to data offload to one small cell, it is noted that in other examples, the macro cell **104** can perform data offload for the UE **110** to multiple small cells.

In some examples, the data offload causes the offloaded data to be communicated between the macro wireless access network node **104** and the respective small cell wireless access network node **108** over the respective backhaul link **116**. In this case, the data offload involves the macro cell **102**, without involving the core network **118**. In other words, the data offload is transparent to the core network **118**.

In other examples, the data offload may be performed at the data gateway **122**, such as a serving gateway (discussed further below). In this case, the serving gateway can send some of the UE's user plane traffic directly to the small cell wireless access network node **108** over a link between the

small cell wireless access network node **108** and the data gateway **122**, such as the S1-U link according to the Long-Term Evolution (LTE) standards. In this case, the data offload is visible to the core network **118**.

As another example, the data gateway **122** can send data to the small cell wireless access network node **108** via the macro wireless access network node **104**. In this case, the macro wireless access network node **104** acts as a router for forwarding data communicated between the data gateway **122** and the small cell wireless access network node **108**.

The data offload procedure (for offloading data of a UE from the macro wireless access network node **104** to a small cell wireless access network node **108**) can be similar to traditional handover procedures, in which a UE is handed over from a source wireless access network node to a target wireless access network node. In a traditional handover procedure, certain system information is transferred between the source wireless access network node and the target wireless access network node. The amount of system information that can be exchanged between the source and target wireless access network nodes can be quite large. If such exchange of system information between wireless access network nodes is also applied to a data offload procedure, then that would result in exchanges of large amounts of system information for each data offload. Because small cells have relatively small coverage areas, the number of occurrences of data offloads performed by the macro wireless access network node to small cell wireless access network nodes can be relatively high as a UE moves around. Also, a large number of UEs in the coverage area of the macro cell **102** can also lead to increased occurrences of data offload.

In accordance with some implementations, to reduce the amount of system information that is exchanged between a macro cell and a small cell for a data offload, certain system information can be communicated between the macro cell wireless access network node and a small cell wireless access network node prior to performing the data offload.

Techniques or mechanisms according to some implementations can be applied in contexts other than the context of a data offload from a macro eNB to a small cell eNB. For example, techniques or mechanisms to reduce system information communication can be applied for device-to-device (D2D) communications, relay communications, and so forth. D2D communication refers to direct wireless communication of data between UEs, where the data does not pass through an eNB. Relay communication refers to wireless communication of data via a relay node that forwards data between an eNB and a UE. More generally, data offload can refer to any communication data that is provided between an intermediate wireless access network node and a UE, where the intermediate wireless access network node is distinct from an eNB. In the small cell context, the intermediate wireless access network node is a small cell eNB. In the D2D context, the intermediate wireless access network node can be a UE. In the relay context, the intermediate wireless access network node can be a relay node.

In the ensuing discussion, reference is made to mobile communications networks that operate according to the Long-Term Evolution (E-UTRA) standards as provided by the Third Generation Partnership Project (3GPP). The E-UTRA standards are also referred to as the Evolved Universal Terrestrial Radio Access (E-UTRA) standards.

Although reference is made to E-UTRA in the ensuing discussion, it is noted that techniques or mechanisms according to some implementations can be applied to other wireless access technologies.

In an E-UTRA network, a wireless access network node can be implemented as an enhanced Node B (eNB), which includes functionalities of a base station and base station controller. Thus, in an E-UTRA network, a macro wireless access network node is referred to as a macro eNB. In an E-UTRA network, small cell wireless access network nodes can be referred to as small cell eNBs.

In an E-UTRA network, the control node **120** in the core network **118** can be implemented as a mobility management entity (MME). An MME is a control node for performing various control tasks associated with an E-UTRA network. For example, the MME can perform idle mode UE tracking and paging, bearer activation and deactivation, selection of a serving gateway (discussed further below) when the UE initially attaches to the E-UTRA network, handover of the UE between macro eNBs, authentication of a user, generation and allocation of a temporary identity to a UE, and so forth. In other examples, the MME can perform other or alternative tasks.

In an E-UTRA network, the data gateway(s) **122** of the core network **118** can include a serving gateway (SGW) and a packet data network gateway (PDN-GW). The SGW routes and forwards traffic data packets of a UE served by the SGW. The SGW can also act as a mobility anchor for the user plane during handover procedures. The SGW provides connectivity between the UE and the PDN **124**. The PDN-GW is the entry and egress point for data communicated between a UE in the E-UTRA network and a network element coupled to the PDN **124**. Note that there can be multiple PDNs and corresponding PDN-GWs. Moreover, there can be multiple MMEs and SGWs.

Pre-Exchanging System Information Between a Macro Cell and a Small Cell

As noted above, to reduce the amount of information exchanged between the macro cell **102** and a small cell **106** for a data offload, certain system information can be exchanged between the macro and small cell eNBs before the data offload is performed. The system information that can be communicated between the macro and small cell eNBs (**104** and **108**, respectively, in FIG. 1) can include common radio resource configuration information. The common radio resource configuration information can be part of system information exchanged between the macro and small cell eNBs **104** and **108**. Common radio resource configuration information, or more generally, common system information, refers to radio resource configuration information (or system information) that is applicable to all UEs served by a given eNB. Radio resource configuration information specifies the configuration(s) of various radio resources used for establishing, maintaining, or otherwise controlling a wireless connection between a UE and an eNB.

FIG. 2 illustrates an example in which a macro eNB **104** exchanges system information with a small cell eNB **108**. The macro eNB **104** includes a database **202** that contains system information of small cells. The database **202** contains system information transmitted (**204**) by the small cell eNB **108**, as well as other small cell eNBs. A “database” refers to a data structure, or multiple data structures, which can store data.

The small cell eNB **108** includes a database **206** that stores system information of the macro eNB **104**. The system information contained in the database **206** was transmitted (**208**) by the macro eNB **104**.

In some examples, the system information exchanged between the macro eNB **104** and the small cell eNB **108** can include system information contained in the following: master information block (MIB), system information block type 1 (SIB1), system information type 2 (SIB2), and optionally system information of other SIB types, such as SIB type 3 (SIB3) to SIB type 5 (SIB5). In other examples, the system information exchanged between the macro eNB **104** and the small cell eNB **108** can include system information in other combinations of SIBs. In further examples, the system information can be other types of system information.

An SIB is broadcast by an eNB within its coverage area. The MIB includes a number of the most essential and most frequently transmitted parameters that are used to acquire other information from the cell, and is transmitted on a broadcast channel (BCH). SIBs other than SIB1 are carried in SystemInformation (SI) messages. SIB1 contains scheduling information pertaining to the other SIBs. A UE first reads the information elements of the MIB to allow the UE to read the information elements of the other SIBs.

The various different types of SIBs can include information that can be used by a UE to determine whether the UE is allowed to access a cell, information relating to cells, radio resource configuration information, power control information, timers, parameters for cell selection and reselection, parameters for configuration of common physical channels, and so forth. More generally, an SIB refers to any message or information element that contains information relating to the mobile communications network or one or more cells, where the information is useable by a UE to establish a connection to a cell of the mobile communications network.

The small cell system information database **202** contains system information of small cells under the coverage of the macro cell **102**. Similarly, the macro cell system information database **206** contains system information of the macro cell **104** in which the small cell eNB **108** is overlaid. If there is any change in system information, an update is performed to update the appropriate one or both of the small cell system information database **202** and the macro cell system information database **206**. System information exchange can be performed periodically or on-demand. For example, for on-demand exchange, the macro eNB **104** can request certain small cell eNBs to provide selected system information, such as MIB or SIB1. After receiving the request, a small eNB can provide the requested information over the backhaul link (e.g. **116**), which can be the X2 interface. In alternative examples, the system information exchange can also be performed periodically; the periodicity can be set to a larger value so that the signaling relating to the system information exchange does not overload the backhaul link. In some implementations, only the macro eNB **104** has the system information of the small cells, while small cell eNBs do not have the system information of the macro cell. In alternative examples, the small cell eNBs may form clusters, and only cluster heads may have the system information of the macro cell.

Note that system information is one type of common radio resource configuration information. While in FIG. 2 system information is used as an example to illustrate the information exchange between the macro eNB and the small cell eNB, other types of common radio resource configuration can be exchanged as well. For example, a common radio resource configuration for the downlink can be sent from one eNB to another eNB, including a Physical Downlink Shared Channel (PDSCH) common configuration and

antenna information. As another example, a common radio resource configuration for the downlink can be sent from one eNB to another eNB, including any one or more of a Physical Uplink Control Channel (PUCCH) common configuration, a Physical Uplink Shared Channel (PUSCH) common configuration, or an uplink sounding reference signal common configuration. In general, one or more types of the common radio resource configuration can be sent from one eNB to another eNB; moreover, such configuration information exchange can be uni-directional or bi-directional.

FIG. 2 also depicts other components of the macro eNB 104 and the small cell eNB 108. The macro eNB 104 includes a control module 210, which can be implemented

116. A new message or a new information element refers to a message or information element that is not provided by current standards, but which may (or may not) be defined by future standards. On the other hand, an existing message or an existing information element refers to a message or information element provided by current standards.

In some examples, system information between eNBs may be carried in a new inter-eNB information element (IE), referred to as AS-Config-Common. The AS-Config-Common IE can be exchanged between the macro eNB 104 and small cell eNB 108 prior to a data offload procedure being performed. The content of an example AS-Config-Common IE is provided below:

```

-- ASN1START
AS-Config-Common ::= SEQUENCE {
    sourcePhysCellId PhysCellId,
    SourceCellConfigList ::= SEQUENCE (SIZE(1.. maxServCell)) OF
SourceCellConfig
    SourceCellConfig ::= SEQUENCE {
        sourceMasterInformationBlock MasterInformationBlock,
        sourceSystemInformationBlockType1 SystemInformationBlockType1(WITH
            COMPONENTS
            {..., nonCriticalExtension ABSENT}),
        sourceSystemInformationBlockType2 SystemInformationBlockType2,
        sourceSystemInformationBlockType3 SystemInformationBlockType3,
            OPTIONAL
        sourceSystemInformationBlockType4 SystemInformationBlockType4,
            OPTIONAL
        sourceSystemInformationBlockType5 SystemInformationBlockType5,
            OPTIONAL
        antennaInfoCommon AntennaInfoCommon,
        sourceDL-CarrierFreq ARFCN-ValueEUTRA,
        ...
    }
}
-- ASN1STOP

```

as machine-readable instructions executable on one or more processors 212 to perform various tasks as described in this disclosure. A processor can include a microprocessor, micro-controller, processor module or subsystem, programmable integrated circuit, programmable gate array, or another control or computing device.

The processor(s) 212 can be coupled to a communications component 214 and one or more storage media 216. The small cell system information database 202 is stored in the one or more storage media 216. The communications component 214 allows the macro eNB 104 to communicate over the backhaul link 116 with the small cell eNB 108.

The small cell eNB 108 includes a control module 218, which can be implemented as machine-readable instructions executable on one or more processors 220 to perform various tasks described in this disclosure. The processor(s) 220 can be coupled to a communications component 222 and one or more storage media 224. The small cell system information database 206 is stored in the one or more storage media 224. The communications component 220 allows the small cell eNB 108 to communicate over the backhaul link 116 with the macro eNB 104.

Although not shown, each of the macro eNB 104 and small cell eNB 108 can include a wireless communications component to communicate wirelessly with UEs.

In some examples, the system information sent from the small cell eNB 108 to the macro eNB 104, or vice versa, can be carried in a new message or a new information element of an existing message over the backhaul link

The system information contained in the foregoing AS-Config-Common IE includes the system information of the MIB, SIB1, SIB2, SIB3, SIB4, and SIB5. Note that in the example above, SIB3, SIB4, and SIB5 are optional elements.

An example of the database 202 (containing small cell system information) kept by the macro eNB 104 is provided below:

Radio configuration	Small cell x	Small cell y	Small cell z	...
Physical cell ID (PCI)				
Antenna ports				
Carrier frequency (or ARFCN)				
MIB DL bandwidth				
PHICH configuration				
...				
SIB1 Cell identity				
Maximum UL transmit power				
TDD configuration				
...				
SIB2 Common radio resource configuration				
UL frequency				
UL bandwidth				
...				
...				

The table above includes various rows that contain information relating to the MIB, SIB1, SIB2, and so forth. The database **202** contains various columns corresponding to different small cells (small cell x, small cell y, and so forth). In a different example, the table may be condensed and only contain selected radio configuration information.

The small cell system information that can be stored in the database **202** can be configured using one of a number of different techniques.

In a first technique, the system information of a small cell is configured by the macro eNB **104**. The macro eNB **104** determines the system information of each associated small cell (associated with macro eNB **104**), stores the system information in the database **202**, and sends the system information to each small cell eNB **108** (such as by use of the AS-Config-Common IE discussed above). The macro eNB **104** is responsible for the initial configuration of the system information in the associated small cells, as well as responsible for system information updates at the small cells.

Using a second technique, the system information of the small cell is configured by a second macro eNB that is different from the macro eNB **104** that is associated with the small cell. This may happen, for example, if the small cell is located at a cell edge between two macro cells. In this case, the system information of the small cell is determined and configured by the second macro eNB, and sent from the second macro eNB to the small cell, such as by use of the AS-config-Common IE discussed above. After the small cell has received the system information from the second macro eNB, the small cell eNB can send the system information (such as by use of the AS-Config-Common IE) to the macro eNB **104**.

System information updates for the small cell can also flow from the second macro eNB to the small cell, and then the updated system information can be sent by the small cell eNB to the macro eNB **104**. It is also possible that after the second macro eNB determines and configures the system information of the small cell, the second macro eNB can directly forward the small cell's system information to the macro eNB **104**.

With a third technique, a small cell eNB can configure its own system information. In this case, the system information of the small cell and updates of the system information can be sent from the small cell eNB to the macro eNB **104**. If the small cell is at the boundary of two macro cells, the small cell eNB can send its system information to both respective macro eNBs. In another example, the macro eNB **104** may determine a subset of the system information configuration for the small cell eNBs, but the small cell eNBs may configure its remaining system information configuration.

System information of a small cell that is common to all UEs served by the small cell is referred to as common system information, or more specifically, common radio resource configuration information. The common system information can be exchanged and updated separately from a data offload procedure. The pre-exchanged common system information does not have to be exchanged again over the backhaul link **116** between the macro and small cell eNBs during a setup of the data offload. For example, during a data offload setup, the small cell eNB **108** does not have to send the small cell common radio configuration information to the macro eNB **104**, since the macro eNB **104** already has the information stored in the database **202**.

To set up the data offload, the macro eNB **104** can send the common system information of the small cell in a message

sent to a UE that is the subject of the data offload. For example, the message can be a Radio Resource Control (RRC) message. An RRC message is used for establishing an RRC connection (a radio connection). RRC is described further in 3GPP TS 36.331, in some examples.

Note that the small cell's neighbor cell information contained in SIB4 and SIB5 may be used by the macro eNB **104** to determine the small cells to be measured by a UE. The macro eNB **104** can notify the UE to measure such small cells, which allows the UE to avoid or reduce the number of instances of performing small cell discovery, which can save power consumption at the UE.

The database **206** (containing macro cell system information) stored at a small cell eNB **108** can have a similar format as the database **202** at the macro eNB **104**. An example of such database **206** is provided below:

Radio configuration	Macro			
	Macro cell x	Macro cell y	cell z	...
Physical cell ID (PCI)				
Antenna ports				
Carrier frequency (or ARFCN)				
MIB	DL bandwidth			
	PHICH			
	configuration			
	...			
SIB1	Cell identity			
	Maximum UL			
	transmit power			
	TDD configuration			
	...			
SIB2	Common radio			
	resource			
	configuration			
	UL frequency			
	UL bandwidth			
	...			
...				

The content of the database **206** is similar to the content of the database **202**, except various columns of the database **206** contain information regarding different macro cells (macro cell x, macro cell y, and so forth). Note that if a small cell is able to observe just one macro cell, then the database **206** would contain just one column for that macro cell.

In alternative implementations, the database **206** is not provided at the small cell eNB **108**. In other words, in such implementations, the macro eNB **104** can store the database **202** containing small cell system information, but the small cell eNBs **108** do not store the database **206** containing macro cell system information.

Examples of common radio resource configuration information that can be stored in the databases **202** and **206** can include the following. Note that the radio resource configuration information can include configuration information for various layers at the eNB, including a physical layer, medium access control (MAC) layer, radio link control (RLC) layer, and a Packet Data Convergence Protocol (PDCP) layer.

The physical layer is the lowest layer in the corresponding node (UE or eNB). The physical layer can include networking hardware for transmitting signals over a wireless link. The MAC layer provides addressing and channel access control mechanisms. The RLC layer can provide at least some of the following example functionalities, as described in 3GPP TS 36.322, including: transfer of upper layer PDUs; error correction, such as by using Automatic Repeat reQuest (ARQ); concatenation, segmentation, and reassembly of

RLC SDUs; reordering of RLC data PDUs; and so forth. The PDCP layer can provide at least some of the following functionalities in the user plane, as described in 3GPP TS 36.323, including: header compression and decompression; in-sequence delivery of upper layer packet data units (PDUs); duplicate detection of lower layer service data units (SDUs); retransmission of PDCP SDUs; and so forth.

The following provides examples of the common radio resource configuration information for the physical layer. Similar configuration information can be provided for the higher layers.

The common radio resource configuration information can include any one or some combination of the following, as examples: downlink carrier frequency, bandwidth, number of antennas at an eNB, Physical Hybrid-ARQ Indicator Channel (PHICH) configuration (relating to the PHICH for carrying acknowledgments of traffic data), selected Physical Random Access Channel (PRACH) configuration common to all served UEs (relating to the PRACH for random access procedures performed by a UE), selected sounding reference signal (SRS) configuration common to all served UEs (relating to an SRS transmitted by a UE), selected Physical Downlink Shared Channel (PDSCH) configuration common to all served UEs (relating to the PDSCH for carrying downlink traffic data), selected Physical Uplink Control Channel (PUCCH) configuration common to all served UEs (relating to the PUCCH for carrying uplink control signaling), selected Physical Uplink Shared Channel (PUSCH) configuration common to all served UEs (relating to the PUSCH for carrying uplink traffic data), and selected uplink power control configuration common to all served UEs (relating to uplink power control at a UE), and so forth.

In addition to common radio resource configuration information, system information can also include dedicated radio resource configuration information, which is specific to a given UE. Examples of the dedicated radio resource configuration information include any one or some combination of the following: antenna configuration, selected PRACH configuration specific to the given UE, selected PDSCH configuration specific to the given UE, selected PUCCH configuration specific to the given UE, selected PUSCH configuration specific to the given UE, selected SRS configuration specific to the given UE, selected uplink power control specific to the given UE, a configuration relating to reporting of a channel quality indicator (CQI), a Scheduling Request (SR) configuration that relates to the SR sent to initiate an uplink data transfer, and so forth.

Data Offload Procedure

FIG. 3 is a flow diagram of an example data offload procedure. As depicted in FIG. 3, the macro eNB 104 sends (at 302) a small cell measurement configuration message to the UE 110. The small cell measurement configuration message configures the UE 110 to perform measurement of radio links to one or more small cells, at the carrier frequency (or frequencies) of the respective small cell(s). In response to the small cell measurement configuration message, the UE 110 performs (at 304) a small cell measurement. If the UE detects (at 306) that a small cell radio link quality is greater than a specified threshold, then the UE 110 sends (at 308) a small cell measurement report that contains measurement data to the macro eNB 104. The small cell measurement report can include an indication of a strength of a radio link with a given small cell (or with multiple small cells), and can identify the small cell (or small cells).

Based on the small cell measurement report from the UE 110, the macro eNB 104 can determine that the UE 110 is within the coverage area of a small cell, and thus, can make

a decision (at 309) to initiate a data offload of at least a portion of traffic data to the small cell. Offloading at least a portion of the traffic data can include offloading traffic data associated with certain radio access bearers. A radio access bearer can refer to an E-UTRAN (Evolved Universal Terrestrial Radio Access Network) Radio Access Bearer (E-RAB), which is used to transport data between a UE and a core network node, such as the SGW 122. A data radio bearer (DRB) is used to transport the data of the E-RAB between a UE and an eNB. Reference to offloading a radio access bearer can refer to either offloading a given E-RAB or the corresponding DRB.

The macro eNB 104 sends (at 310) an Offload Request message to the small cell eNB 108 that is part of the small cell to which data offload is to be performed. The Offload Request message can be sent over the backhaul link 116 between the macro eNB 104 and the small cell eNB 108. The Offload Request message can include certain information, including information identifying the radio access bearer(s) to be offloaded, UE profile information (to identify the UE that is the subject of the data offload), quality-of-service (QoS) profile information (to describe the QoS associated with communications with a UE 110), and other information.

The Offload Request message can also indicate whether the data offload is to include downlink data only, uplink data only, or both downlink and uplink data. The Offload Request message may also include flow control parameters such as threshold values for the flow control functions between the macro cell and the small cells.

In response to the Offload Request message, the small cell eNB 108 can make an admission decision (at 311) to accept the requested data offload. The small cell eNB 108 then sends (at 312) a data offload response to the Offload Request message. This offload response is referred to as an Offload Request Acknowledgment message to the macro eNB 104. The Offload Request Acknowledgment message can also be sent over the backhaul link 116. The Offload Request Acknowledgment message can indicate whether the small cell eNB 108 has accepted or denied the Offload Request.

In situations where the Offload Request Acknowledgment message indicates that the small cell eNB 108 has accepted the Offload Request, the Offload Request Acknowledgment message can further identify the radio access bearer(s) that is (are) accepted by the small cell eNB 108. Note that the small cell eNB 108 can accept just a subset of the radio access bearers identified in the Offload Request message from the macro eNB 104. Alternatively, the small cell eNB 108 can accept all of the radio access bearers identified in the Offload Request message.

Note that the small cell eNB 108 can indicate in the Offload Request Acknowledgment whether the data offload is for downlink data only, uplink data only, or both downlink and uplink data, based on the Offload Request and the available resources of the small cell eNB 108.

Note also that the macro eNB 108, depending upon what has been accepted by the small cell eNB 108, can find one or more other small cells to fulfill the data offload. Alternatively, the macro eNB 104 can decide to partition the data offload to multiple small cells. For example, downlink data offload can be provided to a first small cell, uplink data offload can be provided to a second small cell, and so forth.

In situations where the Offload Request Acknowledgment indicates that the Offload Request has been denied, the Offload Acknowledgment can identify a cause of the denial.

In some examples, the Offload Request Acknowledgment can also include random access information, including a

dedicated preamble. The random access information, including the dedicated preamble, can be used by the UE to perform a random access procedure with the small cell eNB 108 to establish a radio connection with the small cell eNB 108. A dedicated preamble can be used by the UE 110, and not by other UEs, to perform the random access procedure to establish the radio connection with the small cell eNB 108.

Tasks **310**, **311**, and **312** are part of a data offload preparation (or setup) phase of the data offload procedure.

The remaining tasks in FIG. 3 after task **312** are part of the execution phase of the data offload procedure. If the Offload Request Acknowledgment message indicates that the Offload Request has been accepted, the macro eNB **104** can send (at **314**) a Small Cell Offload command (e.g. in an RRC message) to the UE **110**, to instruct the UE **110** to start the establishment of a second radio connection with the small cell identified in the Small Cell Offload command. The Small Cell Offload command can include information about the small cell that is to be used by the UE **110** to establish the second radio connection with the small cell.

For example, the information can include the random access information that was included in the Offload Request Acknowledgment message from the small cell eNB **108** to the macro eNB **104**. Also, the information in the Small Cell Offload command can include both common and dedicated radio resource configuration information, as discussed above.

The Small Cell Offload Command can also specify multiple small cells for the data offload. Additionally, the Small Cell Offload Command can specify that the data offload is downlink data only, uplink data only, or both downlink and uplink data, so that the UE 110 can allocate resources accordingly.

In response to the Small Cell Offload command sent at **314**, the UE **110** performs (at **318**) an attachment procedure with the small cell eNB **108**, for establishing a radio connection with the small cell eNB **108**. In the small cell attachment procedure, the UE **110** can send a PRACH with the dedicated preamble that was included in the Small Cell Offload command.

After sending of the Offload Request Acknowledgment (at 312) indicating acceptance of the Offload Request, the small cell eNB 108 is ready to receive data from and transmit data to the macro eNB 104. After receipt of the Offload Request

Acknowledgment (at **312**) accepting the Offload Request, the macro eNB **104** can send (at **320**) downlink data for the UE **110** to the small cell eNB **108** (assuming that downlink data is part of the data offload). The downlink data can be sent from the macro eNB **104** to the small cell eNB **108** over the backhaul **116**. In response to the downlink data received at **320**, the small cell eNB **108** can forward (at **322**) the downlink data to the UE **110**. In alternative implementations, downlink data for the UE **110** is sent (at **324**) from the SGW **122** to the small cell eNB **108**, either over the S1-U link or indirectly through the macro eNB **104**.

The UE **110** can also send (at **326**) uplink data to the small cell eNB **108** (assuming that uplink data is part of the data offload). The small cell eNB **108** in turn forwards (at **328**) the uplink data to the macro eNB **104**. In alternative implementations, the small cell eNB **108** can transfer the uplink data (at **330**) directly to the SGW **122** or indirectly to the SGW **122** through the macro eNB **104**.

As part of the Offload Request message sent at **310** in FIG. **3**, the macro eNB **104** can transfer certain UE context to the small cell eNB **108**. The UE context can include the following information:

UE radio capability, such as information identifying which radio access technology (e.g. E-UTRA, UTRA, etc.) the UE can use and/or information regarding UE category, physical layer and radio frequency parameters;

UE security capability and security context (which is provided in cases where a Packet Data Convergence Protocol (PDCP) layer is implemented in the small cell eNB **108**); and

dedicated radio resource configuration in the macro eNB 104, which can be reused in the small cell without modification.

In some examples, a modified version of a HandoverPreparationInformation message (traditionally used to set up a handover of a UE between eNBs) can be used to transfer the foregoing UE context. Note, however, that the common radio resource configuration information in the macro eNB **104** does not have to be transferred from the macro eNB **104** to the small cell eNB **108** as part of the data offload procedure, as would traditionally be included in the HandoverPreparationInformation message. A new DataOffloadPreparationInformation IE can be included in the HandoverPreparationInformation message (new elements are underlined), such as in the example below:

```
-- ASN1START
HandoverPreparationInformation ::= SEQUENCE {
criticalExtensions
    CHOICE {
        c1
            SEQUENCE{
                handoverPreparationInformation-r8
                HandoverPreparationInformation-r8-IEs,
                dataOffloadPreparationInformation
                DataOffloadPreparationInformation-IEs,
                spare6 NULL, spare5 NULL, spare4 NULL,
                spare3 NULL, spare2 NULL, spare1 NULL
            },
        criticalExtensionsFuture
            SEQUENCE { }
    }
}

DataOffloadPreparationInformation-IEs ::= SEQUENCE {
ue-RadioAccessCapabilityInfo
UE-CapabilityRAT-ContainerList,
as-Config
AS-Config-dedicated
OPTIONAL,
rrm-Config
RRM-Config
OPTIONAL,
}

HandoverPreparationInformation-r8-IEs ::= SEQUENCE {
ue-RadioAccessCapabilityInfo
UE-CapabilityRAT-ContainerList,
as-Config
AS-Config
OPTIONAL,
rrm-Config
RRM-Config
OPTIONAL,
-- Cond HO
```

-continued

as-Context	AS-Context	OPTIONAL, -- Cond HO
nonCriticalExtension	HandoverPreparationInformation-v920-IEs	OPTIONAL
}		
HandoverPreparationInformation-v920-IEs ::= SEQUENCE {		
ue-ConfigRelease-r9	ENUMERATED {	
	rel9, rel10, rel11, spare5, spare4, spare3,	
	spare2, spare1, ...}	OPTIONAL, -- Cond
HO2		
nonCriticalExtension	HandoverPreparationInformation-v9d0-IEs	OPTIONAL
}		
HandoverPreparationInformation-v9d0-IEs ::= SEQUENCE {		
lateNonCriticalExtension	OCTET STRING	
OPTIONAL,		
nonCriticalExtension	HandoverPreparationInformation-v9e0-IEs	
OPTIONAL		
}		
HandoverPreparationInformation-v9e0-IEs ::= SEQUENCE {		
as-Config-v9e0	AS-Config-v9e0	OPTIONAL, -- Cond
HO2		
nonCriticalExtension	HandoverPreparationInformation-v1130-IEs	
OPTIONAL		
}		
HandoverPreparationInformation-v1130-IEs ::= SEQUENCE {		
as-Context-v1130	AS-Context-v1130	OPTIONAL, -- Cond
HO2		
nonCriticalExtension	SEQUENCE { }	OPTIONAL
}		
-- ASN1STOP		

Note that in the DataOffloadPreparationInformation IE, just the dedicated Access Stratum (AS) configuration is included. Note that the AS-Config-Dedicated IE is a new inter-eNB information element that provides just dedicated AS configuration information (which includes the dedicated radio resource configuration information discussed above) between the macro eNB and the small cell eNB. An example of such AS-Config-Dedicated IE is set forth below:

```
-- ASN1START
AS-Config-Dedicated ::=
  SEQUENCE {
    sourceMeasConfig      MeasConfig,
    sourceRadioResourceConfig RadioResourceConfigDedicated,
    sourceSecurityAlgorithmConfig SecurityAlgorithmConfig,
    sourceUE-Identity      C-RNTI,
  }
-- ASN1STOP
```

The AS-Config-Dedicated IE contains a measurement configuration, dedicated radio resource configuration, security algorithm configuration, and UE identity.

Note also that the DataOffloadPreparationInformation IE does not include the AS-Context IE, which is used to carry information for re-establishing an RRC connection in case of RRC connection failure. This is because in a data offload, the UE would maintain its RRC connection with the macro eNB **104**, such that re-establishment of an RRC connection would not have to be performed.

The measurement configuration in the AS-Config-Dedicated IE provides a configuration of measurements existing in the source eNB when the data offload was triggered. The dedicated radio resource configuration information provides the radio resource configuration for radio bearers existing in the source macro cell when the data offload was performed. The source security algorithm configuration information provides the AS integrity protection and AS ciphering algorithm that is used in the source macro cell.

The Offload Request message and the Offload Request Acknowledgment message (**310** and **312**, respectively, in FIG. 3) each may include a new DataOffloadControlInfo IE. An example of this IE is provided below.

```
-- ASN1START
DataOffloadControlInfo ::=
  SEQUENCE {
    targetPhysCellId
    carrierFreq
    carrierBandwidth
    additionalSpectrumEmission
    offloadTimer
    newUE-Identity
    radioResourceConfigCommon
    radioResourceConfigDedicated
    offloadingdirectionConfig
    rach-ConfigDedicated
    OPTIONAL, -- Need OP
    ...,
  }
-- ASN1STOP
```

In the DataOffloadControlInfo IE, a RadioResourceConfigDedicated IE is included—this IE contains dedicated radio resource configuration information, but does not include common radio resource configuration information.

A new offloadTimer IE includes an offload timer that can be used to specify the time window for the UE to perform a random access procedure to the small cell after the data offload. A new offloadingdirectionConfig IE specifies the data offload direction, such as downlink only, uplink only or both uplink and downlink.

Information Sent by Macro Cell to UE

After receiving the Offload Request Acknowledgment message (at 312) from the small cell eNB 122, the macro eNB 104 may send an RRCConnectionReconfiguration message to the UE to ask the UE to setup radio connections to the small cell. The RRCConnectionReconfiguration message can provide the Small Cell Offload command sent at 314 in FIG. 3. In some examples, a new RRCConnectionReconfigurationDataOffload IE can be included in the RRCConnectionReconfiguration message. The RRCConnectionReconfigurationDataOffload IE can be used to carry the common radio resource configuration of the small cell that is stored in the database 202 at the macro eNB 104 (FIG. 2).

An example of the RRCConnectionReconfigurationDataOffload IE is provided below.

```
-- ASN1START
RRCConnectionReconfiguration ::= SEQUENCE {
    rrc-TransactionIdentifier      RRC-TransactionIdentifier,
    criticalExtensions             CHOICE {
        c1                        CHOICE {
            rrcConnectionReconfiguration-r8      RRCConnectionReconfiguration-r8-IEs,
            rrcConnectionReconfigurationDataOffload RRCConnectionReconfigurationDataOffload,
            spare6 NULL, spare5 NULL, spare4 NULL,
            spare3 NULL, spare2 NULL, spare1 NULL
        },
        criticalExtensionsFuture      SEQUENCE { }
    }
}
RRCConnectionReconfiguration-r8-IEs ::= SEQUENCE {
    measConfig          MeasConfig          OPTIONAL, -- Need ON
    mobilityControlInfo MobilityControlInfo  OPTIONAL, -- Cond HO
    radioResourceConfigDedicated RadioResourceConfigDedicated OPTIONAL, -- Cond HO-
toEUTRA
    securityConfigHO    SecurityConfigHO    OPTIONAL, -- Cond HO
    nonCriticalExtension RRCConnectionReconfiguration-v890-IEs OPTIONAL --
Need OP
}
RRCConnectionReconfigurationDataOffload ::= SEQUENCE {
    DataOffloadControlInfo      DataOffloadControlInfo
    radioResourceConfigCommon   RadioResourceConfigCommon
    measConfig                  MeasConfig          OPTIONAL, -- Need ON
    securityConfigHO            SecurityConfigHO      OPTIONAL, -- Need ON
}
...
}
-- ASN1STOP
```

The DataOffloadControlInfo IE is described further above. The radioResourceConfigCommon IE contains the common radio resource configuration information. The measConfig IE contains a measurement configuration that provides a configuration of measurements to be made by UE in the small cell eNB. The securityConfigHO IE provides the AS integrity protection and AS ciphering algorithm that is to be used by the UE in the small cell.

Unlike in the handover case where the handover command is transparent to the source eNB, here the RRCConnectionReconfiguration message is composed by the macro eNB 104 after receiving the response from the small cell eNB 108. This is because in the handover case, it is expected that the target eNB will take over control of the UE after handover is completed. In the data offload case, however, the

RRC connection to the macro eNB 104 remains in place after the data offload. The UE maintains a single RRC connection to the macro eNB 104. The offloading direction allows the UE to know whether it should receive downlink offload data only, transmit uplink offload data only, or both, through the small cell eNB 108.

In this case, the UE does not have to monitor the small cell downlink for possible system information changes in the small cell. If there is a change of small cell system information, the small cell can send an update to the macro cell and the macro cell can send the new system information to the UE. In another example, the small cell may directly provide the updated system information to the UE via the dedicated signaling connection if a signaling connection between the UE and the small cell exists.

A UE may acquire the small cell system information directly from the small cell downlink after receiving a data offload command from the macro cell. In this case, it may take longer time for the UE to setup a connection to the small cell.

UE Procedure for Data Offload

If the RRCConnectionReconfiguration message received by a UE includes a DataOffloadControlInfo IE, and the UE is able to comply with the configuration included in this

message, the UE can perform the following tasks. The underlined text refers to new tasks, while the remaining tasks are performed according to current standards.

(new) start a data offload timer with the timer value set to the offloadTimer IE, as included in the DataOffloadControlInfo IE;

if the carrierFreq IE is included:

consider the target cell to be one on the frequency indicated by the carrierFreq IE with a physical cell identity indicated by the targetPhysCellId IE;

else:

consider the target cell to be one on the frequency of the source primary cell with a physical cell identity indicated by the targetPhysCellId IE;

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start synchronising to the downlink of the target cell;
 (new) establish a new MAC connection associated with
 the target cell;
 re-establish PDCP for all offloaded resource blocks (RBs)
 that are established;
 re-establish RLC for all offloaded RBs that are estab-
 lished;
 apply the value of the newUE-Identity IE as the Cell
 Radio Network Temporary Identifier (C-RNTI) in the
 target cell;
 configure lower layers associated with the target cell in
 accordance with the received radioResourceConfig-
 Common IE;
 configure lower layers associated with the target cell in
 accordance with any additional fields, not covered in
 the previous, if included in the received DataOffload-
 ControlInfo IE;
 configure lower layers associated with the target cell in
 accordance with the received radioResourceConfigDedicated IE;
 if the RRCConnectionReconfiguration message includes
 the measConfig IE and the offloadingdirectionConfig
 IE:
 perform a measurement configuration procedure;
 (new) send the RRCConnectionReconfigurationComplete
 message to the source eNB;
 (Perform random access to the target cell)
 if MAC successfully completes the random access pro-
 cedure:
 stop data offload timer;
 apply the parts of the CQI reporting configuration, the
 SR configuration and the SRS configuration that do
 not involve the UE having to know the subframe
 number (SFN) of the target primary cell, if any;
 apply the parts of the measurement and the radio
 resource configurations for which the UE has to
 know the SFN of the target primary cell (e.g. mea-
 surement gaps, periodic CQI reporting, SR configu-
 ration, SRS configuration), if any, upon acquiring the
 SFN of the target primary cell;
 the procedure ends.

If the UE cannot apply any of the configurations, the UE
 may send a data offload failure message to the macro eNB
104.

The UE may also send a data offload failure message to
 the macro eNB **104** if the data offload timer expires before
 the random access procedure is completed.

System Architecture

FIG. 4 illustrates example protocol layers in the macro
 eNB **104** and the small cell eNB **108**. The macro eNB **104**
 can include an inter-cell scheduler **402**, which is responsible
 for radio access bearer setup for both the macro eNB **104**
 and small cell eNBs in the coverage area of the macro eNB
104.

The macro eNB **104** also includes a protocol stack **404**,
 which includes layers that provide specified procedures for
 performing communications. In FIG. 4, a MAC layer **406**
 and physical layer **408** of the protocol stack **404** are
 depicted. The physical layer **408** can include networking
 hardware for transmitting signals over a wireless link. The
 MAC layer **406** provides addressing and channel access
 control mechanisms.

The small cell eNB **108** also includes a protocol stack
410, which includes a MAC layer **412** and a physical layer
414. The protocol stack **410** of the small cell eNB **108**
 is used in communications between the small cell eNB **108** and
 a UE (such as **110** in FIG. 1), while the protocol stack **404**

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of the macro eNB **104** is used in communications between
 the macro eNB **104** and the UE.

The protocol stacks **404** and **410** depicted in FIG. 4 are
 user plane protocol stacks. In addition to the MAC and
 physical layers shown in FIG. 4, there can be other protocol
 layers, including a PDCP layer and an RLC layer. As shown
 in FIG. 4, the protocol stack **404** in the macro eNB **104**
 includes an RLC layer **420** and a PDCP layer **422**. The
 PDCP layer **422** is above the RLC layer **420**, which is above
 the MAC layer **406**. The protocol stack **410** of the small cell
 eNB **108** may or may not include the PDCP and RLC layers,
 depending on where a user plane split occurs.

Which protocol layers are included in the small cell eNB
108 depends on where a user plane protocol stack is split in
 the macro eNB **104**. Splitting a user plane protocol stack at
 a given point results in multiple user plane paths, with one
 user plane path through the macro eNB and another user
 plane path through the small cell eNB. The splitting can be
 performed at one of several different points in the user plane
 protocol stack.

Various modules described above, including those
 depicted in FIGS. 2 and 4, can be implemented as machine-
 readable instructions, which can be stored in a computer-
 readable or machine-readable storage medium (or storage
 media). The storage medium or storage media can include
 different forms of memory including semiconductor
 memory devices such as dynamic or static random access
 memories (DRAMs or SRAMs), erasable and program-
 mable read-only memories (EPROMs), electrically erasable
 and programmable read-only memories (EEPROMs) and
 flash memories; magnetic disks such as fixed, floppy and
 removable disks; other magnetic media including tape;
 optical media such as compact disks (CDs) or digital video
 disks (DVDs); or other types of storage devices. Note that
 the instructions discussed above can be provided on one
 computer-readable or machine-readable storage medium, or
 alternatively, can be provided on multiple computer-read-
 able or machine-readable storage media distributed in a
 large system having possibly plural nodes. Such computer-
 readable or machine-readable storage medium or media is
 (are) considered to be part of an article (or article of
 manufacture). An article or article of manufacture can refer
 to any manufactured single component or multiple compo-
 nents. The storage medium or media can be located either in
 the machine running the machine-readable instructions, or
 located at a remote site from which machine-readable
 instructions can be downloaded over a network for execu-
 tion.

In the foregoing description, numerous details are set
 forth to provide an understanding of the subject disclosed
 herein. However, implementations may be practiced without
 some or all of these details. Other implementations may
 include modifications and variations from the details dis-
 cussed above. It is intended that the appended claims cover
 such modifications and variations.

What is claimed is:

1. A method comprising:

receiving, by a first wireless access network node from a
 second wireless access network node, information of
 the second wireless access network node, the informa-
 tion useable to perform a data offload from the first
 wireless access network node to the second wireless
 access network node, wherein the information of the
 second wireless access network node received by the
 first wireless access network node comprises random

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access information for use by the UE to perform a random access procedure with the second wireless access network node; and
 sending, by the first wireless access network node to a user equipment (UE), a message containing the information comprising:
 information of a radio resource for use by the UE to establish a wireless connection with the second wireless access network node as part of the data offload, wherein the information of the radio resource contained in the message sent by the first wireless access network node to the UE is included as part of common radio resource configuration information broadcast by the first wireless access network node to a plurality of UEs, information relating to integrity protection and a ciphering algorithm to be used by the UE with the second wireless access network node, and
 the random access information for use by the UE to perform the random access procedure with the second wireless access network node.

2. The method of claim 1, wherein the first wireless access network node is a macro wireless access network node, and the second wireless access network node is a small cell wireless access network node.

3. The method of claim 1, wherein the information of the second wireless access network node is received by the first wireless access network node from the second wireless access network node in an offload response that is responsive to an offload request sent by the first wireless access network node to the second wireless access network node.

4. The method of claim 3, wherein the offload response comprises an Offload Request Acknowledgment message.

5. The method of claim 1, wherein the message sent by the first wireless access network node to the UE comprises a Radio Resource Control (RRC) message.

6. The method of claim 1, wherein the information of the second wireless access network node received by the first wireless access network node comprises information regarding a direction of the data offload, and wherein the information contained in the message sent by the first wireless access network node to the UE includes the information regarding the direction of the data offload.

7. The method of claim 6, wherein the direction of the data offload is selected from among downlink data only, uplink data only, or both downlink and uplink data.

8. The method of claim 1, wherein the information contained in the message sent by the first wireless access network node to the UE includes a measurement configuration that provides a configuration of measurements to be made by UE in a cell of the second wireless access network node.

9. The method of claim 1, wherein the information contained in the message sent by the first wireless access network node to the UE includes an offload timer value that specifies a time window in which the UE is allowed to perform a random access procedure with the second wireless access network node for the data offload.

10. A first wireless access network node comprising:

an interface to communicate with a user equipment (UE); and

at least one processor configured to:

receive, from a second wireless access network node, information of the second wireless access network node, the information useable to perform a data offload from the first wireless access network node to the second wireless access network node, wherein the information of the second wireless access net-

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work node received by the first wireless access network node comprises random access information for use by the UE to perform a random access procedure with the second wireless access network node; and

in response to the information received from the second wireless access network node, generate an offload command and send, to the UE, the offload command comprising:

information of a radio resource for use by the UE to establish a wireless connection with the second wireless access network node as part of the data offload,

information relating to integrity protection and a ciphering algorithm to be used by the UE with the second wireless access network node as part of the data offload, and

the random access information for use by the UE to perform the random access procedure with the second wireless access network node.

11. The first wireless access network node of claim 10, wherein the at least one processor is configured to:

send, to the second wireless access network node, an offload request to request the data offload; and

receive, from the second wireless access network node, an offload response responsive to the offload request, the offload response including the information of the second wireless access network node.

12. The first wireless access network node of claim 10, wherein the offload command sent by the first wireless access network node to the UE is part of a Radio Resource Control (RRC) message.

13. The first wireless access network node of claim 10, wherein the information of the radio resource is included as part of:

common radio resource configuration information.

14. The first wireless access network node of claim 10, wherein the offload command sent by the first wireless access network node to the UE further comprises:

identifying information that identifies a plurality of small cells to which communication of data is to be offloaded, wherein the second wireless access network node is part of one of the plurality of small cells identified by the identifying information.

15. The first wireless access network node of claim 10, wherein the offload command sent by the first wireless access network node to the UE further comprises:

a measurement configuration that provides a configuration of measurements to be made by the UE in a cell of the second wireless access network node.

16. A user equipment (UE) comprising:

an interface to communicate with a first wireless access network node; and

at least one processor configured to:

receive, from the first wireless access network node, an offload command generated by the first wireless access network node, the offload command to cause a data offload to a second wireless access network node, and the offload command comprising:

information of a radio resource of the second wireless access network node,

information relating to integrity protection and a ciphering algorithm to be used by the UE with the second wireless access network node,

a measurement configuration that provides a configuration of measurements to be made by the UE in a cell of the second wireless access network node, and

random access information for use by the UE to perform
the random access procedure with the second wireless
access network node; and
use the information of the radio resource of the second
wireless access network node and the information
relating to the integrity protection and the ciphering
algorithm to establish a wireless connection with the
second wireless access network node as part of the
data offload from the first wireless access network
node to the second wireless access network node.

17. The UE of claim 16, wherein the first wireless access
network node is a macro wireless access network node, and
the second wireless access network node is a small cell
wireless access network node.

18. The UE of claim 16, wherein the offload command is
included in a Radio Resource Control (RRC) message from
the first wireless access network node that received infor-
mation from the second wireless access network node.

19. The UE of claim 16, wherein the offload command
further includes:

common radio resource configuration information includ-
ing the information of the radio resource.

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